Renewable Enegy Question #8: What is Michigan's long-term potential for more wind, solar, hydro, biomass, landfill gas, and other renewable sources?

Michigan has the technical potential to meet all of its electricity needs from renewable sources. Even after adjusting renewable energy potential based on economic and market limitations, it still has the potential to use renewables to generate nearly twice its 2012 electricity demand—led primarily by onshore wind, solar, and bioenergy.[1] And while it is important to note that not all of this technical potential can or should be tapped due to conflicting land use needs, cost considerations, transmission constraints, and other hurdles, Michigan still has strong, diverse and cost-effective resources available to significantly increase its use of renewable energy above the current 10 percent by 2015 requirement.

Solar: According to an analysis conducted by the National Renewable Energy Laboratory (NREL), Michigan has vast solar power potential, both in the development of utility-scale photovoltaic (PV) systems as well as distributed generation systems on residential and commercial buildings. After accounting for cost projections and geographic limitations, NREL estimates the long term market potential for solar in Michigan at approximately 38,260 GWh per year; which is more than one-third of all electricity generation in the state in 2012.

Wind: Onshore wind resources in Michigan have the potential to generate approximately 143,901 GWh of power annually using turbines on towers that are 80 meter tall. This is more than 1.3 times the total state-wide electricity demand in 2012. Significantly more wind resources are also available offshore on Michigan's Great Lakes.

Bioenergy: Bioenergy is the largest source of renewable energy currently deployed in Michigan. There are two types of bioenergy resources that are potential energy sources in Michigan. First, there is a large supply of sustainable cellulosic biomass resources, which includes energy crops, agriculture and forest residues, as well as mill and urban wood wastes. These resources can be used to produce electricity in a dedicated biomass facility or it can be co-fired (up to 10 or 15 percent) at existing coal plants. In addition, there is a potential to generate electricity from methane captured at existing landfills or wastewater treatment facilities. Michigan has already tapped much of its landfill gas potential.

Geothermal: Like most non-western U.S. states, Michigan does not have potential for producing electricity from conventional, hydrothermal forms of geothermal energy. However, with enhanced geothermal system (EGS) technology, Michigan has the potential to tap into significant new energy resources. EGS draws energy from hot rock at greater depths than conventional geothermal systems—approaching the depths of oil and gas wells—to expand the economically recoverable amount of heat and power stored under the Earth's surface.

Hydropower: Hydropower is the second largest source of renewable energy currently deployed in Michigan. While Michigan is unlikely to expand its conventional hydropower resources by further damming waterways, there is potential for increased electricity generation from smaller, more sustainable run-of-the-river hydropower systems.

(GWh)	Total Estimated Technical Potential in Michigan	Potential after current economic and market limitations	2012 Electricity Generation
Solar	5,290,013	38,261	33
Urban Utility-Scale Photovoltaic	50,845	38,261	~33
Rural Utility-Scale Photovoltaic	5,215,640		

[1] Note: Technical potential accounts for land-use and topographic constraints. Economic limitations include constraints related to projected technology costs and projected fuel costs. Market limitations include constraints related to policy, regulation, and investment.

Rooftop Photovoltaic	23,528		
Wind	1,883,709	143,901	1,108
Onshore Wind Power	143,908	143,901	1,108
Offshore Wind Power	1,739,801	NA	0
Bioenergy	15,795	15,795	3,326
Cellulosic biomass feedstocks	14,687	14,687	2,448
Landfill Gas	1,108	1,108	878
Geothermal	457,850	1,289	~0
Hydrothermal Power	0	0	0
Enhanced Geothermal Systems & Co-Produced	457,850	1,289	0
Hydropower	2,486[2]	2,470	1,305
Total	**7,645,955**	**200,608**	**4,894**
2012 State-Wide Electricity Generation			106,609

Resources:

1) NREL - U.S. Renewable Energy Technical Potentials: A GIS-Based Analysis. Online at http://www.nrel.gov/docs/fy12osti/51946.pdf.

2) EIA Electricity Production Monthly. Online at http://www.eia.gov/electricity/.

3) Chaudhari, M., L. Frantzis, T. Hoff. September 2004. Navigant Consulting. *PV Grid Connected Market Potential under a Cost Breakthrough Scenario*. Navigant Consulting, Cambridge, MA. Online at http://www.ef.org/documents/EF-Final-Final2.pdf.

4) U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy, Wind Powering America Program. 2010. Wind Maps and Wind Resource Potential Estimates. February. Available online at: http://www.windpoweringamerica.gov/wind_maps.asp#potential

5) Walsh, M. 2008. *U.S. Cellulosic Biomass Feedstock Supplies and Distribution*. June 24. Oak Ridge, TN: M&E Biomass. (Biomass Potential at $90/dry ton). Online at http://ageconsearch.umn.edu/bitstream/7625/2/U.S.%20Biomass%20Supplies.pdf; accessed April 22, 2013.

6) Environmental Protection Agency. Landfill Methane Outreach Program. Available at: http://www.epa.gov/lmop/

7) Petty, S. and G. Porro. 2007. "Updated U.S. Geothermal Supply Characterization, "National Renewable Energy Laboratory Presented at the 32nd Workshop on Geothermal Reservoir Engineering Stanford, California January 22–24, 2007 NREL/CP-640-41073. March 2007. http://www.nrel.gov/docs/fy07osti/41073.pdf

8) Table B-1. DOE. EERE. "Feasibility Assessment of the Water Energy Resources of the United States for New Low Power and Small Hydro Classes of Hydroelectric Plants," January 2006 DOE-ID-11263. Online at http://www1.eere.energy.gov/water/pdfs/doewater-11263.pdf; accessed April 22, 2013.

9) Union of Concerned Scientists. 2009. *A Bright Future for the Heartland.* Online at http://www.ucsusa.org/assets/documents/clean_energy/A-Bright-Future-for-the-Heartland.pdf.

[2] The hydropower numbers reported only include hydropower that has not yet been developed. I added that to the current generation to get total potential